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Gold Recycling in the United States in 1998

By Earle B. Amey

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FLOW STUDIES FOR RECYCLING METAL COMMODITIES IN THE UNITED STATES

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FOREWORD

As world population increases and the world economy expands, so does the demand for natural resources. An accurate assessment of the Nation's mineral resources must include not only the resources available in the ground but also those that become available through recycling. Supplying this information to decisionmakers is an essential part of the USGS commitment to providing the science that society needs to meet natural resource and environmental challenges.

The U.S. Geological Survey is authorized by Congress to collect, analyze, and disseminate data on the domestic and international supply of and demand for minerals essential to the U.S. economy and national security. This information on mineral occurrence, production, use, and recycling helps policymakers manage resources wisely.

USGS Circular 1196, "Flow Studies for Recycling Metal Commodities in the United States," presents the results of flow studies for recycling 26 metal commodities, from aluminum to zinc. These metals are a key component of the U.S. economy. Overall, recycling accounts for more than half of the U.S. metal supply by weight and roughly 40 percent by value.

Charles G. Groat
Director

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CONVERSION FACTORS

Most measurements in this report are in metric units, but troy ounces are used in some discussions because international gold prices are reported per troy ounce. Conversion factors are provided below.

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot
	Mass	
gram (g)	0.03527	ounce avoirdupois
kilogram (kg)	2.205	pound avoirdupois
kilogram (kg)	32.1507	troy ounce
metric ton (t, 1,000 kg)	1.102	short ton (2,000 pounds)
troy ounce (troy oz)	31.10	gram
	Other	
gram per metric ton (g/t)	0.0292	troy ounce per short ton

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ABSTRACT

In 1998, 175 metric tons (t) of refined gold was recovered by U.S. refiners from old and new scrap. The overall recycling rate was 29 percent when scrap consumption was compared with apparent domestic supply. Sources of old scrap included discarded jewelry, dental materials, plating solutions, and electronic equipment. A very high old scrap recycling efficiency of 96 percent was reached in 1998, the supply of old scrap peaked, gold prices were at an 18-year low, and substantial amounts of old scrap were exported. U.S. net exports of old scrap had a gold content of 28 t.

INTRODUCTION

This report describes trends in consumption, loss, and recycling of gold-containing materials in the United States in 1998, as depicted in the U.S. gold materials flow diagram (fig. 1). The purpose of the materials flow study was to illustrate the extent to which gold was being recycled and to identify recycling trends.

Because of its high value, gold has been recycled through the ages. Modern jewelry that incorporates recycled gold could contain atoms of gold from an earring worn by Helen of Troy or a nugget of gold used in the 4th millennium B.C. to barter for ingots of crude copper at a Mediterranean seaport. Gold's high recycling rate is further illustrated by the fact that most of the gold ever mined can be accounted for (Lucas, 1993). Of an estimated 125,000 metric tons (t) of gold mined from historical times through 1998, only about 15 percent is thought to have been lost or used in dissipative industrial processes or to be otherwise unaccounted for or unrecoverable. Of the remaining 106,000 t, an estimated 34,000 t is in official stocks held by central banks, and about 72,000 t is privately held as coin, bullion, and jewelry (Amey, 1999). The total amount of gold ever mined is equivalent in volume to an 18-meter cube (Green, 1993, p. 4).

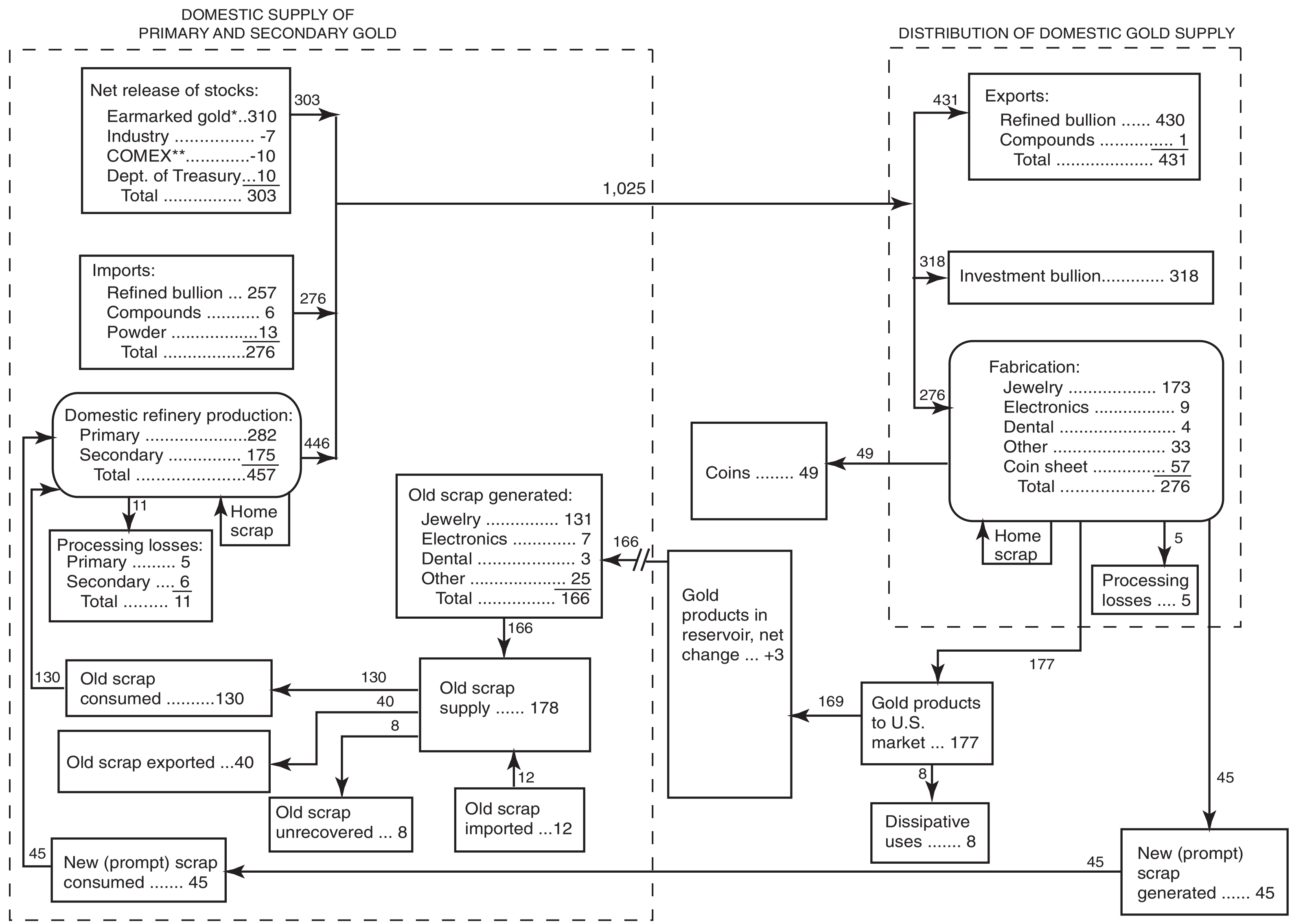
It has been said that gold is forever; its high intrinsic and monetary value dictates that, in time, most of it will be recycled. In 1998, 175 t of refined gold was recovered by domestic refiners from old and new scrap. The value of this refined gold was about $1.7 billion, when it was calculated on the basis of the average gold price for 1998 of $295.24 per troy ounce (see appendix). The overall recycling rate was 29 percent when scrap consumption was compared with apparent domestic supply (table 1). This percentage is on the low side of the range of 20–70 percent estimated for gold recycling during the past 50 years. Gold recycling, however, cannot be viewed strictly from the U.S. market. International political and economic events that may influence the gold commodity market may be outweighed by developments perceived to favor gold as a medium of exchange.

In 1998, secondary unrefined gold-bearing materials valued by the U.S. Census Bureau in excess of $370 million were exported, principally for refining to commercial-grade gold bullion. These materials are designated in figure 1 as old scrap exported, which had a gold content of 40 t. The principal recipient nations were Canada and the United Kingdom. Old scrap imported by domestic refiners during 1998, and originating in Canada, the Dominican Republic, Mexico, and elsewhere, had a gold content of 12 t and was valued at over $100 million. Thus, the value of the 28 t of gold in net exports of old scrap in 1998 was about $270 million.

GLOBAL GEOLOGIC OCCURRENCE OF GOLD

Estimates of gold's abundance in the Earth's crust range from 3 to 4 parts per billion (ppb) gold (Lucas, 1985). This abundance is equivalent to about 1 gram of gold in 300 t of rock. Although data were sparse, gold was more abundant in mafic than in felsic igneous rocks and in sandstone than in other sedimentary rocks. Much of the gold that has been mined came from quartz veins or from alluvial deposits in streams. As these easily accessible sources became increasingly rare, gold mining shifted to bulk ores of lesser grades. South Africa has about half of all world gold resources, and Brazil and the United States have about 10 percent each (Amey, 1999). If the South African deposits are considered to be paleoplacers, alluvial deposits account for somewhat more than half of the world's gold resources (Simons and Prinz, 1973, p. 266).

Native gold is fairly insoluble in almost all surficial environments and is unaffected during weathering and decomposition of rocks. Hence, it occurs in extremely small amounts in freshwater, about 0.03 ppb, and even less in seawater, 0.011 ppb (Simons and Prinz, 1973, p. 266). In environments where humic or other acids exist, gold can become soluble, forming nuggets when it precipitates.



* Earmarked gold means the net flow of gold to the U.S. market from foreign stocks held in the New York Federal Reserve Bank.

**COMEX indicates gold released from private sector stocks as reported by the Commodity Exchange (COMEX) Division of the New York Mercantile Exchange.

Figure 1. U.S. gold materials flow in 1998. Values are in metric tons of contained gold. Sources of data are described in the section titled "Sources of Gold Scrap."

Table 1. Salient statistics for U.S. gold scrap in 1998.
[Values in metric tons of contained gold, unless otherwise specified]

Old scrap:	
Generated[1]	166
Consumed[2]	130
Value of old scrap consumed	$1.234 billion
Recycling efficiency[3]	96 percent
Supply[4]	178
Unrecovered[5]	8
New scrap consumed[6]	45
New-to-old-scrap ratio[7]	25:75
Recycling rate[8]	29 percent
U.S. net exports of scrap[9]	28
Value of U.S. net exports of scrap	$272 million

[1]Gold content of products theoretically becoming obsolete in the United States in 1998. Dissipative uses were excluded.

[2]Gold content of products that were recycled in 1998.

[3](Old scrap consumed plus old scrap exported) divided by (old scrap generated plus old scrap imported plus any old scrap stock decrease or minus any old scrap stock increase).

[4]Old scrap generated plus old scrap imported.

[5]Old scrap supply minus old scrap consumed minus old scrap exported minus old scrap stock increase.

[6]Including prompt industrial scrap but excluding home scrap.

[7]Ratio of quantities consumed, in percent.

[8]Fraction of the gold apparent supply that is scrap on an annual basis. It is defined as (consumption of old scrap plus consumption of new scrap) divided by apparent supply (see appendix), measured in weight and expressed as a percentage.

[9]Trade in scrap is assumed to be principally in old scrap. Net exports are exports of old scrap minus imports of old scrap.

GOLD PRODUCTION PROCESSES

Gold ores can be classified into two groups: (1) free milling ores from which native gold is recovered by crushing, gravity separation, amalgamation, and leaching processes, such as cyanidation, and (2) refractory ores, such as tellurides and other auriferous sulfides, that yield gold after complex oxidizing processes (Roskill Information Services, 1995, p. 1). Many gold mining operations recover gold from cyanide leach solutions by precipitation with carbon in the pulp. The activated carbon collects gold from the cyanided pulp until the pulp contains 300 to 400 troy ounces of gold per metric ton of carbon. Gold with accompanying silver is desorbed or stripped from the carbon with a strong alkaline cyanide-alcohol solution. The precious metals are recovered from the strip solutions by electrodeposition on a stainless-steel-wool cathode. The cathode deposit is refined into a doré, a gold-silver bullion of variable composition, which is sent to a refiner.

Gold is refined by chlorination in the molten state (Miller process) and by electrolysis (Wohlwill process). Generally, gold bullion made by the Miller process is 996 to 997 fine (99.6 to 99.7 percent), and bullion made by the Wohlwill process is 999.5 to 999.8 fine (99.95 to 99.98 percent) (Lucas, 1985). Gold purity is expressed as fineness in parts per thousand or, in the case of gold alloys, in karats (parts per 24).

When gold is associated with copper ores, it travels with the base metal through concentration and smelting to the refining stage. It is eventually separated from the anode slimes, which accumulate in electrolytic copper refiring cells, and is recovered as gold bullion in the precious-metals refinery (Lucas, 1985).

GOLD MARKET PRICES AND USE PATTERNS

The dollar price for gold decreased throughout 1998. The Engelhard Corporation's industries quotation (listed weekly in *Platt's Metals Week*) showed that the daily price of gold ranged from a low of nearly $275 per troy ounce on August 28, 1998, to a high of about $314 on April 24. The average for the year was, to the nearest dollar, $295. The 1997 prices ranged from about $298 to $368 and averaged $332 per troy ounce (Amey, 2000, p. 33.1).

In 1998, estimated uses of gold were jewelry, which includes arts, 63 percent; coins, 21 percent; industrial, which includes electronics and other assorted uses, 15 percent; and dental, 1 percent. U.S. gold-use patterns in 1998 were similar to those of the rest of the world (Murray and others, 1998, p. 5). U.S. gold consumption by end-use sector from 1978 through 1998 is depicted in figure 2. Two significant factors increased gold use: (1) the popularity of the American Eagle gold coin produced by the U.S. Mint since 1987 and (2) seven consecutive years (1992–98) of growth in unit sales for gold jewelry in the United States. Much of the latter increase came from outside the Northeast sector, which has been the traditional heartland of the U.S. jewelry industry.

GOLD STATISTICS

Various components of the U.S. gold materials flow were studied to specify the factors affecting recycling and to identify the ultimate direction and disposition of domestic supply. Companies that supply gold to end users were regularly contacted by the U.S. Geological Survey (USGS) to update data used to estimate the total amount of gold consumed by industry. Because new suppliers become active every year, the estimates were slightly understated but were still accurate to two significant figures. Most of the data used in this report relating to production, supply, and consumption of gold were obtained from USGS publications on minerals. Most of the remaining data were obtained from company reports and industry publications.

SOURCES OF GOLD SCRAP

Sources of old scrap and new scrap are key features of the U.S. gold materials flow diagram (fig. 1). Statistical data for domestic consumption of new and old scrap in

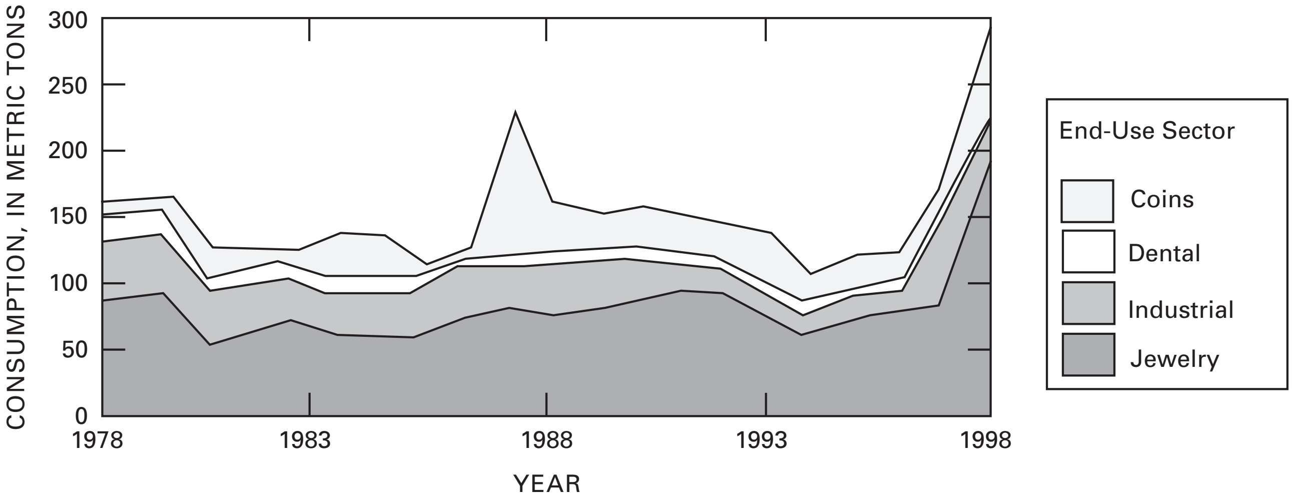


Figure 2. U.S. gold consumption by end-use sector from 1978 through 1998. Values are in metric tons of contained gold. Industrial uses include the manufacture of electronic devices.

1998 were collected by the USGS as a single quantity. The amount of new scrap was calculated by estimating that it generally is about 17 percent of the total input for the fabrication process. Gold coin cuttings, which became new scrap, were estimated to be 14 percent of the total input. Consequently, the amount of old scrap consumed may be obtained by subtracting the amount of new scrap consumed from the total scrap consumed.

Figure 1 shows that the domestic supply of primary and secondary gold consists of (1) inputs from domestic refinery production, (2) imports, and (3) the net release of gold stocks from foreign countries, U.S. industry, the U.S. Department of the Treasury, and the private sector. Statistical data for domestic refinery production were collected by the USGS as primary and secondary quantities. Statistical data for gold imports were collected by the U.S. Census Bureau (written commun.). Statistical data for the net release of gold to the U.S. market from foreign stocks were reported by the New York Federal Reserve Bank (written commun.); data on industry stocks were collected by the USGS; Government stocks were reported in the *Federal Reserve Bulletin* (1999); and private sector stocks were reported by the Commodity Exchange (COMEX) Division of the New York Mercantile Exchange (CRU International, Ltd., 1999).

Refined bullion, compounds, and powder were exported, bought as investments, or made into jewelry, electronic components, coins, and other products. More than 99 percent of the gold bullion coins were American Eagle coins, which were purchased at precious-metal dealers, brokerage companies, coin dealers, and participating banks strictly for investment. Coins are treated separately from other fabricated gold products in figure 1 to show the amount of gold held for investment purposes in 1998. Statistical data for coins were collected by the U.S. Mint (Shirley Jones-Keller, written commun., 1999); for gold exports, by the U.S. Census Bureau (written commun.); and for jewelry, electronic components, and other products, by the USGS. Investment data were obtained by calculating what remained of the domestic gold supply after gold exports and fabricated gold products were deducted.

Data discussed in the following sections are summarized in table 1.

OLD SCRAP GENERATED

Old scrap consists of gold-containing products that have been discarded after use or after becoming obsolete. The old scrap generated in 1998 had a gold content of 166 t. The amount of gold in old scrap consumed, 130 t, amounted to 78 percent of the gold in old scrap generated and had a value of more than $1.23 billion. Net exports of old scrap had a gold content of 28 t.

The old scrap component of the gold supply was perhaps the most difficult component to quantify. In many areas of the world, especially where the holding of gold was encouraged by tradition, secondary gold, especially that derived from relatively crude gold jewelry, changed hands both locally and internationally from purchasers to goldsmiths and back again to purchasers. This flow was often in response to variations in the gold price and usually could not be followed statistically. In addition, some old scrap was lost because, in practice, gold cannot be economically recovered from all manufactured products; recovery becomes increasingly difficult as gold-bearing electronic products become more miniaturized.

NEW SCRAP

New scrap is generated during manufacturing processes and, for the most part, remains the property of the manufacturers; it is continually recirculated. A considerable amount of scrap is generated in manufacturing operations, but, because of strict controls over waste materials in precious-metals plants, nearly all of this home-generated scrap can be recovered. In 1998, 45 t of new scrap was consumed, which was about 25 percent of the total scrap consumed.

DISPOSITION OF GOLD SCRAP

The feature generally attributed to the metals recycling industry—high volume of comparatively low value metal—is quite unlike that of gold. Gold recycling deals with relatively low volumes of very highly valued raw material. Therefore, proper handling, accountability, and security against loss and theft during generation, collection, and distribution are important additional burdens not shared by most other metals industries. Many gold consumers have elaborate collection systems for reclaiming new gold scrap that results from the manufacture of gold products. Thus, there are very small losses. All materials that may come into contact with gold during the processing and handling are recycled. Gloves, aprons, and dust masks worn by gold workers and the dust, or sweeps, from the shops are collected and processed to get additional quantities of gold. At times, even the floors of the refineries are burned to recover gold. Similarly, a specialized field of secondary gold recovery gleans gold from defunct gold-processing operations (Lucas, 1993).

The high intrinsic value of gold scrap shipped to a refiner dictates that special precautions be taken to assure preservation of the payable gold content. For example, raw electronic scrap may be collected, disassembled, or shredded, and gold components separated from other less valuable ones before shipping to a refiner (Lucas, 1993). At the higher end of the spectrum, gold scrap created during the manufacture of jewelry will go directly to the refiner. These are only a few examples of the scrap forms that typically cross a refiner's loading dock. Each shipment can also be accompanied by documentation, ranging from title, insurance, and customs papers to licensing and transport documents that address local, State, and national environmental and other regulatory requirements.

Each refining transaction is negotiated individually between the refiner and the customer. Ordinarily, refining schedules or outlines of services, capabilities, and charges are used by refiners to establish the basis upon which the negotiations will proceed (Lucas, 1993). Included in these negotiations are lot size and character of the product to be refined. Other factors may be minimum or standard treatment charges, charges for preparation and assaying, charges or penalties for the presence of deleterious elements, and instructions regarding the basis of payment. The customer may elect to sell the material outright, may have the scrap refined and the gold prepared to contract specifications and returned (toll refining), or may elect to draw an equivalent value of refined metal from a pool account established by the refiner.

A shipment is assigned a control number upon arrival at the refinery, then is weighed, evaluated, and subjected to a variety of preparatory processes, depending upon the shipment's character (Lucas, 1993). Preparation may include incineration, roasting or melting, and pulverizing, shredding, or grinding to produce a homogeneous product. At this point, one or more representative samples are drawn so that assays can determine the character and content of the original shipment. The refiner may combine similar lots to form large batches. These batches are sent to the refining process, which may include pyrometallurgical, hydrometallurgical, and electrochemical processes to separate gold from associated impurities.

OLD SCRAP RECYCLING EFFICIENCY

Old scrap recycling efficiency shows the relation between what was theoretically available for recycling and what was not recovered. This relation is defined as (old scrap consumed + old scrap exported) divided by (old scrap generated + old scrap imported ± scrap stock changes), measured in weight and expressed as a percentage. The old scrap generated in 1998 was made up of jewelry and art products, industrial and electronic scrap, and dental debris. The typical content of gold in electronic scrap was about 300–400 grams per metric ton (ASM International, 1998, p. 1192). Most old scrap came from jewelry and electronic manufacturers' buy-back programs. A very high old scrap recycling efficiency of 96 percent was reached in 1998, the supply of old gold scrap peaked, gold prices were at an 18-year low, and substantial amounts of old gold scrap were exported.

INFRASTRUCTURE OF GOLD SCRAP

The historical and universal recognition of gold as a highly valuable commodity assures that virtually every conceivable recycling method will be used to recapture it from scrapped materials. Industrial gold consumers, the principal sources of supply, keep their gold-bearing scrap moving into the market on an established, routine basis for security reasons. On the other hand, private individuals may hoard or sell gold in response to the prevailing or anticipated economic or political climate. For example, a person may hoard gold coins, bars, and jewelry as a hedge against inflation or in anticipation of economic or political upheaval and may sell gold coins, bars, and jewelry in times of relative stability when alternative, dividend-paying investments may be more attractive. Most of the conditions and incentives that have encouraged high rates of gold recycling exist today and will probably exist in the future. Gold, more than any other recyclable material, continues to be a highly sought after commodity in the secondary metals market.

SCRAP COLLECTION SYSTEMS

Refiners throughout the world recover secondary gold from scrap. In the United States in the past 20 years, as much as 70 percent and as little as 25 percent of the scrap came from current manufacturing operations, and the remainder came from old scrap, such as discarded jewelry, dental materials, used plating solutions, and junked electronic equipment. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into commercial products. Most of the domestic scrap was processed by refiners centered in the New York, N.Y., and Providence, R.I., areas. Other centers were in California, Florida, and Texas, although the trend in 1998 seemed to be toward a less centralized industry. Scrap dealers processed the scrap and then shipped the upgraded product to refiners and fabricators for further treatment and refining. The U.S. Department of Defense (DOD) recovered significant quantities of gold from military scrap. Other Federal agencies either participated in the DOD recovery program or had their own; all of the scrap reclaimed through these programs was sent to refiners for further processing in 1998.

Gold-bearing scrap was paid for on the basis of gold content, as determined by analytical tests. The market price for gold was paid on the day that the refined product was available for sale. Processing charges and adjustments for processing losses were deducted from the total value in settling payments. Aside from dealer-processors and refiners, there were no markets for scrap gold. The market is limited by the Federal Trade Commission requirement for karat identification of jewelry alloys, which in effect requires gold refiners to know the chemical analysis of the alloys they purchase and requires gold refiners to separate the constituents of scrap to assure meeting karat standards (Public Law 226, 1906).

TRADE

In 1998, U.S. exports of gold scrap decreased for the second straight year (to 40 t), after 5 years of increase, while imports increased for the second year in a row (to 12 t). As it had been for many years, the United States was still a net exporter of gold scrap. Prices for gold waste and scrap imported and exported in 1998 averaged $190 and $197 per troy ounce, respectively; the annual average price for gold was $295 per troy ounce.

Exports of refined gold bullion were 430 t; the United Kingdom (209 t) was the principal destination, followed by Switzerland (79.6 t), Australia (47 t), and Canada (46.7 t). More than 8 percent of all gold exported was scrap. Imports for consumption of refined gold bullion in 1998 were 257 t; Canada (96.5 t) was the largest supplier, followed by Australia (62.4 t), Brazil (32.7 t), and Peru (23.1 t). More than 4 percent of all gold imports were scrap.

PROCESSING OF GOLD SCRAP

Scrap metals can be processed by either primary or secondary refiners. The latter handle only scrap, such as discarded jewelry, electronics, and dentistry products. Other types of scrap include gold-bearing slimes, solutions, and sludges; precipitates from base (lead and zinc) or precious metals recycled from smelters and refiners; and old gold coins, medals, and previously hoarded low-purity nonaccredited gold bars. Primary refiners receive doré directly from the mine in addition to gold scrap that has been amassed by collectors. Most refiners will not accept scrap lots of less than 0.5 t, and many have a 2.5-t minimum (Garino, 1994). Many small shipments are obtained from collection points throughout the Nation, and some even come from overseas. At the higher end of the spectrum of value, scrap generated during the manufacture of karat gold jewelry will go directly from the manufacturer to the smelter-refiner. Scrap originating at the jewelry manufacturer is closely monitored by the company from generation through collection, packaging, and transportation to the recovery plant.

Upon arrival at the refinery, each shipment is assigned a control number. Each scrap shipment is accurately weighed, blended, and analyzed for precious-metal content before payment is made (Lucas, 1993). It is common for a representative of the source company to be present during this step. Once the refinery owns the scrap, impurities such as lead, copper, and silver are removed from the gold by a high-temperature chlorination step (Miller process).

The purified scrap that remains after chlorination is electrorefined (Wohlwill process) to recover gold directly in what is called a fine gold cell. High-grade anodes are suspended from positive bus bars by platinum hooks, and the gold is plated out into thin sheets of pure gold called starting sheets. Gold produced in this manner is 999.75 fine or better. The sludge that remains in the cell contains platinum-group metals, which can be recovered by various methods that are usually patented by individual companies for their own use.

Products derived from secondary materials have a wide range of shapes and forms, including some bars of pure gold, sheet gold, wire, tubing, foils, leaf, casting grain, gold-plating solutions, gold-bearing organometallic liquids, and conductive inks and pastes. Probably the greatest loss in gold fabrication occurs in gold electroplating plants where fouled solutions (containing cyanides that must be labeled "toxic waste") or depleted solutions are sometimes discarded (Recycling Today, 1990, p. 69). Likewise, some old scrap is lost, because, in practice, gold cannot be economically recovered from all manufactured products.

OUTLOOK

Barring any unforeseen changes in the established pattern of world secondary supply, the quantity of gold generated from secondary sources was forecast to be about the same in 1999 as it was in 1998 (Klapwijk and others, 1999, p. 7), which is more than 20 percent of the total world gold supplied to fabricators, investors, and exporters. Developments that may increase the percentage of scrap entering the market include the following:

1. Any decline in world gold production, if not offset by refined supplies from other sources (such as central bank sales or bullion sales from the private sector), could lead to higher prices and thereby cause more material to enter the recycling stream.
2. The establishment of more efficient, centralized scrap collection and recovery centers could encourage higher rates of recycling.
3. Continued growth in the demand for gold jewelry in rapidly industrializing nations, such as those of the Far East and China, could result in increased recycling of older style jewelry as fashion tastes evolve with improved standards of living.

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APPENDIX—DEFINITIONS

apparent consumption. Primary plus secondary production (old scrap) plus imports minus exports plus adjustments for Government and industry stock changes.

apparent supply. Apparent consumption plus consumption of new scrap.

dissipative use. A use in which the metal is dispersed or scattered, such as paints or fertilizer, making it exceptionally difficult and costly to recycle.

doré. A gold-silver bullion of variable composition.

gold bullion. Refined gold in the shape of bars or ingots.

home scrap. Scrap generated as process scrap and consumed in the same plant where generated.

new scrap. Scrap produced during the manufacture of metals and articles for both intermediate and ultimate consumption, including all defective finished or semifinished articles that must be reworked. Examples of new scrap are borings, castings, clippings, drosses, skims, and turnings. New scrap includes scrap generated at facilities that consume old scrap. Included as new scrap is prompt industrial scrap—scrap obtained from a facility separate from the recycling refiner, smelter, or processor. Excluded from new scrap is home scrap that is generated as process scrap and used in the same plant.

new-to-old-scrap ratio. New scrap consumption compared with old scrap consumption, measured in weight and expressed in percent of new plus old scrap consumed (for example, 40:60).

old scrap. Scrap including (but not limited to) metal articles that have been discarded after serving a useful purpose. Typical examples of old scrap are electrical wiring, lead-acid batteries, silver from photographic materials, metals from shredded cars and appliances, used aluminum beverage cans, spent catalysts, and tool bits. This is also referred to as post-consumer scrap and may originate from industry or the general public. Expended or obsolete materials used dissipatively, such as paints and fertilizer, are not included.

old scrap generated. Gold content of products theoretically becoming obsolete in the United States in the year of consideration, excluding dissipative uses.

old scrap recycling efficiency. Amount of old scrap recovered and reused relative to the amount available to be recovered and reused. Defined as (consumption of old scrap (COS) + exports of old scrap (OSE)) divided by (old scrap generated (OSG) plus imports of old scrap (OSI) plus a decrease in old scrap stocks (OSS) or minus an increase in old scrap stocks), measured in weight and expressed as a percentage:

$$\frac{\text{COS} + \text{OSE}}{\text{OSG} + \text{OSI} + \text{decrease in OSS or} - \text{increase in OSS}} \times 100$$

old scrap supply. Old scrap generated plus old scrap imported plus old scrap stock decrease.

old scrap unrecovered. Old scrap supply minus old scrap consumed minus old scrap exported minus old scrap stock increase.

price. Based on the unit value of gold in materials. Values of gold in this report are calculated on the basis of the average gold price for 1998 of $295.24 per troy ounce. Daily prices that were averaged came from the Engelhard Corporation's industries quotation (listed weekly in *Platt's Metals Week*).

recycling. Reclamation of a metal in usable form from scrap or waste. This includes recovery as the refined metal or as alloys, mixtures, or compounds that are useful. Examples of reclamation are recovery of alloying metals (or other base metals) in steel, recovery of antimony in battery lead, recovery of copper in copper sulfate, and even recovery of a metal where it is not desired but can be tolerated—such as tin from tinplate scrap that is incorporated in small quantities (and accepted) in some steels only because the cost of removing it from tinplate scrap is too high and (or) tin stripping plants are too few. In all cases, what is consumed is the recoverable metal content of scrap.

recycling rate. Fraction of the apparent metal supply that is scrap on an annual basis. It is defined as (consumption of old scrap (COS) plus consumption of new scrap (CNS)) divided by apparent supply (AS), measured in weight and expressed as a percentage:

$$\frac{\text{COS} + \text{CNS}}{\text{AS}} \times 100$$

scrap consumption. Scrap added to the production flow of a metal or metal product.